This is basically a problem since predefining the torque/torsion angle in conjunction with the number of process operations is independent of the location of the process tool, it depending solely on the sequence in processing or the predefined number of operations.

Prior Art

A1 Cont'd

DE 36 37 236 C2 disclosing the preamble of claims 1, 15 assures correct processing to a certain extent by enabling various process operations differing in sequence to be implemented with the aid of a "smart" process tool without requiring the operator to make any changes to the control system or having to enter new data. The control and monitoring arrangement disclosed therein for a process tool, more particularly a screw driver or nut runner, comprises, as shown in Fig. 1a, an emitter 2 located in the process station 1 which emits a signal 3 in a restricted zone 6 which contains information explicitly identifying the corresponding process site 4 on the workpiece. As evident in Fig. 1b it is furthermore provided for that the complete process station 1 is divided into several zones 6a, 6b each having emitters 2a, 2b for each of the process sites 4a, 4b on the workpiece.

When a process tool 7 including a detector 2C applied thereto, as shown in Fig. 1c, is moved into the zone 6, 6a, 6b the detector 2c applied to the process tool 7 detects the corresponding signal 3 and the control and monitoring arrangement sets the torque provided for the process site 4, 4a, 4b. As evident from Fig. 1f when the recognizing means formed by the emitter and detector identifies the tool in a certain zone (process station), design process parameters are read by the programming means 8 from a memory 9 and output to the tool 7, whereby during processing a comparator 10 compares the actual values to the design values.

Page 4, after the first full paragraph insert the following:

--DE 197 23 365 A1 describes a method and a system for remachining a part in which the position of the tool is established by means of an emitter/detector assembly. More particularly, at least one emitter unit or detector unit is assigned to the workstation for emitting and detecting respectively signals to/from a detector unit or emitter unit assigned to the tool and connecting the processing means.

US 5,186,303 relates to a device for determining the location and orientation of an object on a substrate, more particularly the deviation from an ideal position. A CCD camera together with a pattern recognizing section is used to identify the actual position of a variable resistor or the like applied to the object.

DE 42 43 724 A1 discusses a method of positioning workpieces with the aid of a camera. The workpiece is positioned (translatory and/or rotationally) as desired with the aid of a camera, an image analyzer and a positioner in obtaining a plurality of typical images of the workpiece whilst being rotated and/or shifted translatory.--

Page 4, starting with the second full paragraph delete all the paragraphs in their entirety through to the last paragraph beginning at the bottom of page 7, ending at the top of page 8 and insert the following:

--Although, as already explained above currently available automated process tools permit processing with programmed process parameters, whereby by sensing the actual

parameters during processing it is also assured that the design process parameters are maintained, recognition can be implemented to "see" whether a process tool is located in a specific zone of the process station, there is nevertheless a requirement for a higher degree of process assurance to prevent an operator from working at wrong sites with unsuitable process parameters, due to a confusion in work schedules, for example.

AB cont'd

It is thus the object of the present invention to sophisticate a process system and a process tool of the aforementioned kind so that it is assured that an operator actually undertakes processing at programmed process sites on the workpiece, independent of the location of the process tool in the process station.

Achievement of the object

This object is achieved by a process system as set forth in claim 1: in accordance with one aspect of this process system a recognizing means is provided which identifies each process site on the workpiece, and thus now there is no assignment of the process tool to a specific zone of the process station, instead the actual site to be processed by the process tool is identified. An operator is thus now free to implement the process operations in any sequence, the system always assuring that the operations predefined by the work schedule in the controller are implemented correctly sited.

The object is also achieved by a process system as set forth in claim 2. In accordance with one aspect of this process system a recognizing means is provided which identifies the location, i.e. the position of the process tool in the process station, the location, i.e. position of the workpiece in the process station and from which it is able to determine the location of the

process tool relative to the process site in each case. Once the location of the process tool and the location of the workpiece has been recognized then - since the process sites on the workpiece are always programmed (for example in a memory) - the system is always able to keep track of whether the process tool has been guided to the corresponding process site, also in the corresponding sequence, where several process sites are concerned, so that here too, the system is able to assign the process tool not, for example, to each zone, as in prior art, but to the process site itself. In other words, identifying the process site is implemented implicitly via locationing.

In accordance with a further aspect of the invention the recognizing means comprises a means for imaging at least one section of the workpiece in which at least one process site is located.

The imaging means may be preferably mounted on the tool or arranged integrally therein. Now, even if an operator moves the process tool anywhere in the process station, it is still assured that the work is done correctly sited, since the portion located ahead of the process tool is explicitly imaged. The imagings are then compared by an image processing means with predefined maps and programmed ting the process parameters is implemented on the basis of the imagings, thus assigning programmed ting of the process parameters explicitly to the imaged, i.e. recognized process site. Preferably the recognizing means comprises an image processing means and an image memory, the image processing means comparing a map imaged by the imaging means with programmed process site maps held in the image memory and outputs an identification signal in identifying a programmed process site to a process parameter programmed ting means when agreement between the imaged map and a memorized process site

map is established. Comparing the image data held in the image memory and the data imaged by the imaging means is preferably done with the aid of a logic, it being good practice to use fuzzy logic for the comparison to reduce the complication thereof.

In accordance with a further embodiment of the invention the imaging means is not applied to the process tool itself but at predefined locations in the process station so that at least part of the process station is imaged in which at least one workpiece is located. Thus, when the workpiece, for example, is moved at a predefined speed through the process station, a specific process site can now be identified. Preferably, the system recognizes whether processing has been done at the identified process site, i.e. when a process tool, likewise identified, is identified in the region of the process site. For identifying the process site and the process tool usual map recognition procedures may be employed.

Preferably the imaging means comprises a video camera or infrared camera. To also identify process sites at concealed or non-illuminated locations the process tool preferably comprises a light source for illuminating the process station or a part thereof ahead of the process tool.

Preferably an enabling means is provided which does not enable processing with the programmed process parameters until the recognizing means has identified a programmed process site. On the basis of the identified process sites a counter means can count how often, in accordance with a work schedule, a process site has been identified and how often processing with programmed process parameters has been implemented at this process site.

The process tool may be preferably a screw driver or nut runner. Preferably the process system comprises a means for sensing actual processing parameters and a means for comparing the sensed actual parameters to the design parameters for controlling the process tool so that in processing the actual parameter is brought into agreement with the design parameter.

In accordance with yet another aspect the process tool is provided with at least one marking and the recognizing means comprises an imaging means for imaging the process station, an image processing means identifying the location of the tool by processing the image of the marking and of the workpiece or at least part of the workpiece.

By means of predefined markings an image processing means is able to analyze movement maps of the process tool in establishing whether a predefined number of operations at each of the process sites has been implemented. More particularly the recognizing means is able to sense the speed at which the workpiece is moved on the basis of time-tracking the change in position of one or more process sites.

When a process tool is provided with several markings then the image processing means is also able to determine the angular orientation to the process site from analyzing the coordinates of both markings relative to the coordinates of the process sites or to a fixed system of coordinates.

Preferably the process tool comprises a set of process units in a predefined orientation. In this case a counter means of the recognizing means is able to enable the process tool at a subsequent process site only when the process tool, i.e. process units have assumed a plurality of

programmed locations relative to the process site, more particularly a predefined number of various angular orientations.

Preferably the recognizing means comprises a workpiece memory for memorizing workpiece data, the image processing means of the recognizing means determining the location (coordinates) of a reference coordinate point of the workpiece image and determines the location of the tool relative to the workpiece by analyzing the spacings between the coordinates of the marking and each process site with reference to the workpiece data held in the workpiece memory, more particulary relative to the data as to the location of the process sites. When the coordinates of the workpiece marking and those of a specific process site agree, or agree at least witin a tolerance range, then the system recognizes that processing is implemented at the corresponding location. On the basis of this recognition the tool can be enabled and/or the design values defined.--

Page 8, delete the paragraphs under the heading beginning with the second full paragraph through to the second paragraph of page 9 and insert the following:

--Further advantageous embodiments and improvements of the invention are set forth in the sub-claims. More particularly the invention comprises embodiments materializing from features claimed or described separately in the claims and subsequent description. The invention will now be detailled by way of its embodiments with reference to the drawing in which:

Figs. 1a-1e is a diagram of a prior art process system including a recognizing means for identifying a tool in a process station;

Fig. 2 is a block diagram of a process system in accordance with a first aspect of the invention;

Figs. 3a, 3b are diagrams of embodiments of a process tool including a recognizing means in accordance with a first aspect of the invention;

Fig. 4 is a diagram of an embodiment of the recognizing means including an imaging means 20a, an image memory 22 and an image processing means 21;--

Page 13, delete the paragraphs starting from the paragraph beginning at the bottom of the page through to the paragraph at the top of page 15 and insert the following:

--As explained at the outset, the process tool operator normally receives a work schedule so that a predefined number of process tools are first implemented e.g. with a M10 adapter bush and then with a M15 adapter bush in sequence. When using the imaging means in accordance with the invention in conjunction with a counter means it can also be assured that the predefined number of process operations has been implemented at the correct process sites, i.e. preventing the operator from attempting to bolt the same site twice whilst some other site is not processed at all. In other words, on the basis of the process site being identified the recognizing means is able to "see" that a process operation has already been successfully implemented at a specific process site, it being then, and only then, that the counter means considers the process operation (consisting of e.g. several individual bolting operations) to be concluded and resumes counting. If the operator attempts to reprocess the already finished process site, then the counter will not

recommence counting and preferably the enabling means will not re-enable the process tool at this process site.

Second Aspect of the Invention

Fig. 5 depicts a block diagram of a process system for processing a workpiece in accordance with a second aspect of the invention. Fig. 6 shows a view similar to that as shown in Fig. 3c in conjunction with the second aspect of the invention.

Referring now to Fig. 6 there is illustrated how in the second aspect of the invention too, a workpiece 5 is arranged in a programmed process station 1 and is processed at a plurality of process sites 4, 4` with programmed process parameters by at least one process tool 7, 7`. A recognizing means 200 is provided to identify the location and/or and angle orientation of the process tool 7, 7` in the process station 1, to identify the location of the workpiece 5 in the process station 1 and to determine therefrom the location of the process tool 7 relative to each process site 4. Once a predefined location of the workpiece (and/or a specific process site on the workpiece) relative to the tool has been recognized, the recognizing means 200 outputs the identification signal ES to the process parameter programming means 8 which, just the same as shown in Fig. 2, reads the corresponding design values from the memory means 9 for outputting to each process tool 7, 7` and to the comparator means 10. During processing , the comparator means 10 compares the actual values to the design values and controls the process tool 7 in the same way as shown in Fig. 2.

Page 22, delete the first two paragraphs and insert the following:

--Accordingly, all embodiments of the first aspect and second aspect may be used in combination for enhanced process assurance. For example, the mounted or integrated imaging means may be used for recognizing difficult access process sites when in the second aspect of the invention the workpiece is not scanned from all sides by means of several imaging means.

Commercial Application

Although the first aspect and second aspect of the invention have been described with reference to an example in automobile production, it is understood that the process system and process tool in accordance with the invention are applicable to any kind of process operation on a workpiece.--

IN THE CLAIMS:

Please cancel claims 1-35 without prejudice or disclaimer.

Please add the following new claims:

--36. A process system including a process tool (7) for processing a workpiece (5) at a plurality of process sites (4) comprising:

a) a recognizing means (20) for identifying each process site (4) on said workpiece (5);

b) a means (8) for programming said process parameters on the basis of an identification signal (ES) characterizing each process site (4) and output by said recognizing means (20); whereby

c) said recognizing means (20) comprises